Wheat agronomy implications for frost

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- Supported by DAFWA and GRDC
2016 coldest spring since 1969 and coldest average, minimum temperature on record since 1910
Frost events in September 2016 Vs Avg. September
Frost damage processes are more complex than we think

• Subzero is a pre-requisite but this does not guarantee freezing of plant tissues
• Pure water can remain liquid to -40°C in absence of nucleators (Rejashekar & Burke, 1996).
• A liquid below its melting point is ‘supercooled’
• Ability to supercool (or prevention of freezing) overrode any plant acclimation (found wheat could supercool and tolerate down to -5°C) (Fuller et al. 2007)
Fuller et al. 2007 *European Journal of Agronomy* 26, 435-441

- Ability to supercool was more important than ‘hardening’ which was generally insignificant at this stage of plant development…
Agronomic implications for frost – Dale frost nursery 2017
Frost x Nitrogen

Hypothesis 1:
Late N ‘soften’ or ‘un-hardens’ wheat to frost

Mace & Trojan

N at seeding and Z33
80+0, 30+0, 30+12.5, 30+25, 30+50, 30+100 N
Softening
Example - Nitrogen induced ‘cold-shock’ in rice

Late nitrogen can induce cold susceptibility in some rice varieties

Sensitive stage at early pollen development
Freeze-hardening

Accumulation of solutes – (anti-freeze) compounds that lower the freezing point
- Important in vegetative winter wheat surviving as low as -30°C
- Not significant in reproductive stage wheat

Does N change sap freezing point?
Osmotic potential – more negative values equals harder to freeze

<table>
<thead>
<tr>
<th>Nitrogen treatment</th>
<th>Osmotic potential (MPa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>80+0</td>
<td>-1.55</td>
</tr>
<tr>
<td>30+0</td>
<td>-1.5</td>
</tr>
<tr>
<td>30+12.5</td>
<td>-1.55</td>
</tr>
<tr>
<td>30+25</td>
<td>-1.6</td>
</tr>
<tr>
<td>30+50</td>
<td>-1.7</td>
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<tr>
<td>30+100</td>
<td>-1.75</td>
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</table>
Osmotic potential – more negative values equals harder to freeze

<table>
<thead>
<tr>
<th>Nitrogen treatment</th>
<th>Osmotic potential (MPa)</th>
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</thead>
<tbody>
<tr>
<td>80+0</td>
<td>-1.43</td>
</tr>
<tr>
<td>30+0</td>
<td>-1.23</td>
</tr>
<tr>
<td>30+12.5</td>
<td>-1.27</td>
</tr>
<tr>
<td>30+25</td>
<td>-1.31</td>
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<tr>
<td>30+50</td>
<td>-1.35</td>
</tr>
<tr>
<td>30+100</td>
<td>-1.39</td>
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</tbody>
</table>

Freezing point depression (°C)
Grain yield – Sown 5th May

<table>
<thead>
<tr>
<th>Nitrogen Treatment</th>
<th>Grain yield (t/ha)</th>
<th>LSD 0.4t/ha</th>
</tr>
</thead>
<tbody>
<tr>
<td>80+0</td>
<td>Mace: 4.0</td>
<td>Trojan: 4.5</td>
</tr>
<tr>
<td>30+50</td>
<td>Mace: 3.0</td>
<td>Trojan: 3.5</td>
</tr>
</tbody>
</table>

- LSD: Least Significant Difference
Grain yield – Sown 9th June

Grain yield (t/ha)

Nitrogen treatment

Mace

LSD = 0.5 t/ha

Trojan

80+0

30+50

Nitrogen treatment
Gaps in yield data limit strength of conclusion here but:

- WA’s nitrogen budgets generally low by global standards
- Reproductive stage frost occurs in areas with high yield potential, do they avoid in-season N?
- There are no reports found that support N making wheat more susceptible to frost
Summary – N x Frost

• Can’t support hypothesis that N increases wheat susceptibility to frost

• We know from the literature that ‘hardening’ processes are negligible in reproductive stage wheat, so perhaps this should come as no surprise.

• Membranes were not tested
  • but no differences in ‘water soaked’ leaves were observed between N treatments but quantification is planned for 2017
Can plant density alter frost susceptibility?

Can low seed rates decrease frost risk?

Do high seed rates increase risk?
Head emergence – Trojan sown 13\textsuperscript{th} May

Heads emerged per week

Date

Trojan 30 20N
Trojan 30 50N
Trojan 60 20N
Trojan 60 50N
Trojan 120 20N
Trojan 120 50N

GRDC UPDATES
Head emergence – Yitpi sown 13th May

Heads emerged per week

- Yitpi 30 20N
- Yitpi 30 50N
- Yitpi 60 20N
- Yitpi 60 50N
- Yitpi 120 20N
- Yitpi 120 50N

Date
2/9/16 7/9/16 12/9/16 17/9/16 22/9/16 27/9/16 2/10/16 7/10/16 12/10/16 17/10/16

Heads emerged per week
0 50 100 150 200 250 300
**Statistical significance for grain yield**

<table>
<thead>
<tr>
<th></th>
<th>TOS1</th>
<th>TOS2</th>
<th>TOS3</th>
<th>TOS4</th>
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</thead>
<tbody>
<tr>
<td><strong>Variety</strong></td>
<td>&lt;.001</td>
<td>&lt;.001</td>
<td>&lt;.001</td>
<td>0.021</td>
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<tr>
<td><strong>Nitrogen</strong></td>
<td>&lt;.001</td>
<td>&lt;.001</td>
<td>0.003</td>
<td>&lt;.001</td>
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<tr>
<td><strong>Seedrate</strong></td>
<td>NS</td>
<td>NS</td>
<td>0.011</td>
<td>0.019</td>
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<tr>
<td><strong>N * SR</strong></td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
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</tbody>
</table>
Grain yield (Variety x Seed rate) 13\textsuperscript{th} May sowing

Grain yield (t/ha)

Seeding rate (kg/ha)
<table>
<thead>
<tr>
<th>Variety</th>
<th>Mace</th>
<th>Magenta</th>
<th>Trojan</th>
<th>Yitpi</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1.333</td>
<td>2.673</td>
<td>2.043</td>
<td>2.931</td>
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<tr>
<td>Nitrogen</td>
<td></td>
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<tr>
<td></td>
<td>20</td>
<td>50</td>
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<tr>
<td></td>
<td>2.092</td>
<td>2.398</td>
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<tr>
<td>Seedrate</td>
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<tr>
<td></td>
<td>30</td>
<td>60</td>
<td>120</td>
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<td></td>
<td>2.268</td>
<td>2.289</td>
<td>2.178</td>
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Despite finding the expected change in phenology, seed rates were smallest factor.
Variety was the biggest source of yield variation in frosted experiments.
Key messages:

Frost is complex and determining damage is challenging

Evidence for late Nitrogen increasing wheat susceptibility to frost is lacking

Low seed rates did not change yield performance in this trial series

Variety choice had the greatest influence – focus on this!